Lecture 9:

Turing's Babies

The father of computing and his offspring

Today's Topics

Short Chronology
Max Newman
Tommy Flowers
The Bombe
The Colossus
The SSEM
The Pilot Ace
The Bendix
The Mosaic
The Deuce
Freddie Williams

A short chronology (1)

23.6.1912 Born, Paddington, London
1926-31 Sherborne School
1930 Death of Christopher Morcom
1931-34 Undergraduate at King's College, Cambridge
1932-35 Studies quantum mechanics, probability, logic
1935 Elected fellow of King's, Camb
1936 *On Computable Numbers...* Submitted
1936-38 Princeton University. Ph.D.
Papers in logic, algebra, number theory
Works with Church & Von Neumann
1938-39 Return to Cambridge.
Introduced to German Enigma cipher problem
1939-40 Devises the Bombe, machine for Enigma decryption

A short chronology (2)

1939-42 Breaking of U-boat Enigma
1943-45 Chief Anglo-American consultant.
Introduced to electronics
1945 NPL, London
1946 Computer design, leading the world, formally accepted
1947-48 Papers on programming, neural nets, and prospects for A.I.
1948 Manchester University

History of Computing

A short chronology (3)

1949 Programming and world's first serious use of a computer
1950 Philosophical paper on machine intelligence: the Turing Test
1950 Elected FRS. Paper on non-linear chemical morphogenesis theory
1952 Arrested and tried as a homosexual, loss of security clearance
1953-54 Unfinished work in biology and physics
7.6.54 Death by cyanide poisoning, Wilmslow, Cheshire.

History of Computing

Max Newman

At Cambridge taught Kilburn, Williams & Turing
Delayed publication of “Computable Numbers”
Sent Turing to Princeton to work with Church
Ran the Newmanry in Bletchley Park
Directed Operations to build Colossus
Went to Manchester after the war
Won a Royal Society Grant in 1946
Introduced Kilburn & Williams to computing
Brought Turing to Manchester in 1948
By 1951 withdrew from the Mark I project
After Turing’s death gave up computing

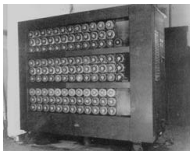
History of Computing

Tommy Flowers

Born December 22, 1905 (London)
Attended London University
Worked Post Office,
Dollis Hill (electronic telephone transmissions)
Served Bletchley 1942
Consulted by Newman, at Turing's suggestion
Colossus constructed at Dollis Hill 1943
Nearly worked on the ACE!
Flowers‘ role revealed in the 1970s
Awarded MBE for wartime service
Honorary doctorate Univ. Newcastle in 1977.
Post Office's first Martlesham Medal. 1980
Died October 28 1998 aged 92

History of Computing

The bombe 1939



The Polish Cipher Bureau BS4

Marian Rejewski
Henryk Zygalski
Jerzy Rozycki

Handed secrets to the British and French in 1939

Not allowed to work at Bletchley.

Welchman & Turing had to re-invent.

History of Computing

The Colossus 1943

Electronic
Built at P.O. Dollis Hill then moved to BP
Operational Dec. 1943
Solved first problem in 10 minutes!
Read paper tape via photo-electric cells at 30mph
Boolean – Sought contradictions
25,000 cps
Pre-programmed
Conditional branching

Newman
Flowers
Turing
Chandler
Coombes

History of Computing

The Pilot Ace

G G Allway, E A Newman, L H Wilkinson.

History of Computing

Pilot Ace: Storage

Serial machine using mercury delay line storage and working at a pulse repetition rate of 1 megacycle/sec.

High speed store
11 long delay lines of 32 words 32 bits 1024μs circulation period
5 short delay lines of 1 word 32 bits 32μs circulation period
2 short delay lines of 2 words 32 bits

Close-up of the ACE showing an array of thermionic valves

History of Computing

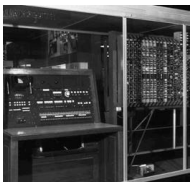
Pilot Ace: Coding

"Three-address code"
Each instruction calls for the transfer of information from one of 32 "sources" to one of 32 "destinations" and selects which of eight long delay lines will provide the next instruction.

This third address is necessary because consecutive instructions do not occupy consecutive positions but are placed in such relative positions that, in so far as is possible, each instruction emerges during the minor cycle in which the current instruction is completed.

History of Computing

Pilot Ace: Instruction Word



Pilot Ace at the Science Museum, London

The structure of the instruction word is as follows:

Next instruction source	Digits 2-4
Source	Digits 5-9
Destination	Digits 10-14
Characteristic	Digits 15-16
Wait number	Digits 17-21
Timing number	Digits 25-29
Go digit	Digit 32

The remaining digits are spare.

History of Computing

Pilot Ace: Portsmouth Connection

Donald Watts Davies was born on 7 June 1924 in Treorchy in the Rhondda Valley.

When his father died the following year, his mother took Donald and his twin sister back to her home town of Portsmouth, where he went to school.

Imperial College, London, first class degrees in both physics and mathematics,
Worked at Birmingham University on atomic research.

Davies at NPL

Joined NPL in September 1947 as a member of the small computer team led by Alan Turing, and with Ted Newman, Jim Wilkinson and others he played a key part in the detailed design and development of Pilot ACE.

History of Computing

The Pilot Ace

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History of Computing

Harry D. Huskey

B.S. (Maths) Idaho 1937.
Master's (Maths) Ohio State 1940
Ph.D. (Maths) Ohio State 1943
Instructor University of Pennsylvania (1943-46).
Worked on the ENIAC project.
Associate Director National Bureau of Standards (Washington)
Designed & built the NBS Western Automatic Computer (SWAC)
fastest computer in existence,
first using standard cathode ray tubes as a *parallel* memory.
Worked on the Pilot Ace
Developed the Bendix G15 computer
small and paved the way for the PC
Initiated the Time-Sharing Project 1963
allowed multiple users to share computer time.

At the console of the SWAC

Today

History of Computing

The Bendix

The Bendix G-15 was a low cost but powerful, internally programmed, digital computer of medium speed.

The basic unit provided a complete, general purpose computing system in a single cabinet.

It was expandable by means of selected accessories.

Used serial logic and time-sharing techniques in the internal design.

History of Computing

The Bendix: Storage

Internal: Magnetic drum.
External: A built-in, searchable, photo-electric reader for punched tape. Magnetic tape storage was optional.

In each case data and commands could be stored interchangeably.

History of Computing

The Bendix: Programming

The command structure was flexible. Fixed or floating point decimal I/O

Allowed double-precision operations with the same ease as single-precision ones.

Facilitated Breakpoints to help with "debugging."

History of Computing

The Mosaic (1947-54)

Ministry of Supply Automatic Integrator and Computer

The MOSAIC was used on tracking and telemetry problems associated with guided weapons, etc.

Built by a Post Office under Dr A. W. M.Coombes. ComPOST!

The computer itself had 1024 40-bit words in delay lines, involving nearly a ton of triple-distilled mercury, 6000 valves, 2000 diodes and dissipating 60 kilowatts, Based on the ACE (and EDSAC)

Although not the earliest of early British computers, MOSAIC was arguably the largest!

History of Computing

The Deuce

Digital **E**lectronic **U**niversal **C**omputing **E**ngine

Two levels of storage (like modern machines)
- High speed storage (mercury delay lines)
- Slow storage (magnetic drum)

I/O Card reader and punch.
All programs were loaded stand-alone from cards

Cards Identical to IBM 80-column punched card
(the IBM scheme for coding data and text could be used)
Binary programs were encoded onto the cards using all the positions, achieving a good level of packing, but making the cards almost impossible to produce or modify by hand.

History of Computing

The Deuce (Optimal Coding)

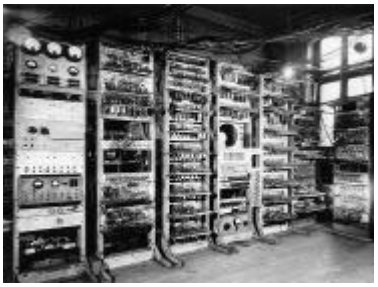
The binary instruction format was very complex.
Each instruction occupied a single row on a punch card.
Specified:
- an operation code and the operands
- a 'wait number'
  - number of clock cycles before the data emerges from the delay line
- a 'timing number'
  - number of clock cycles before the next instruction emerges from the delay line containing the executable code

Optimising a program meant arranging the instructions in the order that would minimize wasted clock cycles.

Thus instructions did not appear on the punch cards in the order in which they would be executed, very complex form a human point of view.

History of Computing

The SSEM or Baby



History of Computing

Freddie Williams 1911-1977

Pre-War Years at Manchester and Oxford

Stockport Grammar School
B.Sc Engineering (Manchester) 1932
M.Sc Engineering (Manchester) 1933
D.Phil (Oxford) 1936 [Circuit & Valve Noise]
Assistant Lecturer Engineering (Manchester)
In the next few years c.20 papers.
Incl. with Blackett on an automatic curve follower for the Hartree Differential Analyser
RAF radar research group at Bawdsey (1939)
[later this became TRE]
D.Sc (Engineering) 1939 [Only 28!]

History of Computing

CRT Storage

Chair of Electrotechnics (Manchester) 1946
TRE were interested in CRT storage and funded Williams' research.
Tom Kilburn / Arthur Marsh seconded

By Autumn 1947 they were able to store 2048 bits over a period of a few hours - "The Williams Tube".

Unlike the Delay Line, it was made out of simple standard components, it was compact, and it did not require temperature control or accurately controlled power supplies. Most importantly, it was a true random-access storage device.

These properties were of course highly significant in it being the first working storage system.